

Comisión Nacional del Agua—National Weather Service

1998 Annual Report

Transfer of the National Weather Service River Forecast System
to Mexico

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¹The Executive Summary and Project Recommendations are preceded by Spanish-language translations.

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Resumen Ejecutivo

La Comisión Nacional del Agua (CNA) y el Servicio Meteorológico Nacional de E.U. (NWS) están desarrollando un proyecto de cooperación para transferir a México la tecnología del NWS en el pronóstico de ríos e inundaciones. Este proyecto se inició a finales de 1996 y continuó a lo largo de 1998 el cual está financiado con fondos del programa multi-anual denominado PROMMA para la modernización de la administración del agua en México.

En apoyo al PROMMA, las dos organizaciones se encuentran en el proceso de adoptar la tecnología de pronóstico que pueda ayudar a México en el manejo de su red más importante de presas y almacenamientos, mejorar el pronóstico de inundaciones y facilitar el establecimiento de esta tecnología a escala regional. Muchas de las actividades que se han programado están enfocadas a la implantación de la tecnología del NWS en el noroeste de México. En 1998 se completó la instalación del sistemas de pronóstico para dos cuencas importantes ubicadas en el noroeste, la cuenca del Río Fuerte y la del Río Yaqui. Actualmente el sistema de pronóstico en estas dos cuencas se encuentra en operación diaria.

Seis ingenieros de la CNA completaron su entrenamiento en la tecnología del sistema de pronóstico durante los años de 1997 y 1998. En 1998 el NWS llevó a cabo numerosas actividades que proporcionaron a la CNA información relacionada con los Sistemas de Apoyo en la Toma de decisiones (DSS) para la operación de almacenamientos. También se reunió con personal de las oficinas regionales y usuarios potenciales del sistema para evaluar la posibilidad de instalar un centro de pronóstico de ríos en el noroeste de México.

El NWS inició la evaluación del uso del radar e imágenes de satélite para la estimación de la precipitación para complementar la información de lluvia de la red actual de medición, comparó los modelos de la CNA y del NWSRFS, tradujo del inglés al español una considerable cantidad de documentos técnicos e inició la evaluación del uso de otras tecnologías para aplicaciones de la GASIR. Otras tecnologías incluyen los sistemas para el manejo de bases de datos que facilitarán la operación de los sistemas de pronóstico en México y el intercambio de información y datos entre las gerencias regionales y oficinas centrales.

En el año de 1997 el NWS y la CNA prepararon el plan preliminar 1996-2001. Durante 1999, el NWS y la CNA revisarán su actual cooperación y prepararán un plan de cooperación a largo plazo para el periodo de 1999-2003.

Executive Summary

The Comisión Nacional del Agua (CNA) and the National Weather Service (NWS) are cooperating in a project to transfer NWS's river and flood forecasting technology to Mexico. Funded by PROMMA, a multi-year program to modernize water management in Mexico, the project began in late 1996 and continued through 1998.

In support of PROMMA, the two organizations are attempting to adopt river forecasting technology that can help Mexico manage its network of major dams and reservoirs, improve forecasting of floods, and facilitate the establishment of this technology at the regional level. Much of the activity to date has been focused on implementing NWS technology in northwest Mexico. Implementation of forecast systems for two important river basins in the northwest, the Río Fuerte and the Río Yaqui, was completed in 1998; both river basin forecast systems now are in daily operation.

Six CNA engineers completed full training on forecast system technology during 1997 and 1998. In 1998, the NWS conducted a workshop that provided CNA with information about reservoir operation Decision Support Systems (DSS's). NWS representatives met with numerous regional staff and potential forecast system users to evaluate the establishment of a river forecast center in northwest Mexico. The NWS also began to evaluate the use of radar and satellite precipitation estimation to complement the current gage network, compared CNA and NWSRFS models, translated considerable technical documentation from English to Spanish, and began to evaluate the use of other technologies in GASIR applications. Other technologies include data base management systems that will facilitate the operation of river forecast systems in Mexico, and the exchange of information and data between regional and headquarters levels.

In 1997, NWS and CNA prepared a preliminary 1996-2001 plan. During 1999, NWS and CNA will review their current cooperation and prepare a long-term cooperative plan for 1999-2003 period.

Introduction

This report documents 1998 activities that the NWS of the National Oceanic and Atmospheric Administration (NOAA) undertook to support the CNA PROMMA project. PROMMA is a program to modernize water management in Mexico and is funded by the Mexican government and the World Bank. The key component of NWS support to CNA is the implementation of the NWS River Forecast System (NWSRFS) in selected river basins in Mexico. The NWSRFS and associated technologies are used operationally on a day-by-day basis at 13 River Forecast Centers (RFC's) in the United States to forecast river flow and floods. This technology has the potential to assist CNA forecast major rivers and manage surface-water infrastructure in those river basins.

CNA and the NWS agreed in principle to a multi-year plan, in which project activities are defined by annual letters of agreement on a calendar-year basis. The first agreement was completed in November 1996 and provided for the procurement of workstations and other activities to initiate

the project. The second agreement was completed in February 1997 and provided for numerous activities that were grouped under seven tasks and were intended to help NWS understand the hydrologic regime and water management practices in Mexico, and CNA understand the NWSRFS and associated technologies. The third agreement was completed in January 1998 and continued many of the activities begun in 1997.

During 1998 several organizations from Mexico and the United States participated in the project. The principal partner with whom the NWS cooperated is the Gerencia de Aguas Superficiales e Ingeniería de Ríos (GASIR). GASIR is responsible for monitoring surface-water resources in Mexico and the management of major rivers and reservoirs. It is an organization that resides in the Technical Sub Directorate of CNA. The Mexican meteorological service, Gerencia de Servicio Meteorológico Nacional (GSMN) is a second major CNA partner and also is in the Technical Sub Directorate. The NWS and GSMN have cooperated on meteorological issues for more than 50 years and continue to cooperate under PROMMA. The NWS also cooperated with the Instituto Mexicano de Tecnología del Agua (IMTA), which is an organization under the Secretaría de Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP), CNA's parent organization. United States organizations that participated in the project include the US Army Corps of Engineers (USACE) and the US Bureau of Reclamation (USBR), which participated in a reservoir management decision-support workshop. Other US participants in the workshop were the Georgia Institute of Technology, the Hydrologic Research Center (HRC), and Riverside Technology Inc. (RTI). Additionally, CNA representatives also visited the NWS West Gulf River Forecast Center as part of their preparation to operate river forecast systems in Mexico. A representative of the NWS Southeastern River Forecast Center (SRFC) also assisted GASIR engineers develop operational river forecasting procedures.

This report consists of an Executive Summary, Introduction, 1998 Project Activities, 1998 Budget, and Recommendations. These recommendations are based upon lessons learned from implementing the NWSRFS in the United States and experience with this project. The recommendations are followed by References and Acronyms used in the report. Finally, because language is an important issue in this project, the Executive Summary and Project Recommendations are provided in English and Spanish.

1998 Project Activities

The 1998 agreement identified 12 tasks that the NWS undertook with the cooperation of GASIR and other CNA organizations. These tasks are listed below and task summaries follow in this section

- 98.1 Río Fuerte Initialization and Calibration
- 98.2 Río Yaqui Initialization and Calibration
- 98.3 Radar Plan
- 98.4 Implement GIS plan, phase 1
- 98.5 River basin inventories
- 98.6 NWSRFS Consulting

- 98.7 PROMMA project management
- 98.8 CNA access to other agencies
- 98.9 DBMS and regional study
- 98.10 Satellite precipitation estimation
- 98.11 GASIR/NWSRFS model comparison
- 98.12 NWSRFS documentation translation

Task 98.1 Río Fuerte Calibration and Initialization

Two important 1998 tasks concerned implementing the NWSRFS in major river basins in northwestern Mexico, the Río Fuerte and the Río Yaqui basins. Their locations are shown in Figure 1. Upon operational implementation in Mexico, the system became known as the Sistema de Pronóstico en Ríos de la CNA (SPRCNA).



During initial preparation of the Río Fuerte system in 1997, one training and cooperative development session was conducted for GASIR and IMTA engineers at RTi's facilities in Fort Collins, Colorado. Three additional sessions were undertaken during 1998.

Hydrologic model calibration training and cooperative development was undertaken from January 26-February 20, 1998. Following this visit to Fort Collins, Mark Woodbury of RTi spent the first week of March in Mexico City and continued technical development work with GASIR and IMTA engineers.

System initialization training and cooperative development was undertaken from March 23-April 17, 1998. Reggina Garza of the NWS Southeast River Forecast Center (SRFC) participated in the preparation of the Río Fuerte SPRCNA and assisted GASIR and RTi engineers develop Río Fuerte operational procedures during this time. Towards the end of the session, the engineers also joined Sezin Tokar of the NWS and RTi representatives in a visit to the NWS West Gulf RFC (WGRFC) in Ft. Worth, Texas on April 6 and 7, where they were briefed on RFC operations. Subsequently, Reggina Garza assisted Mark Woodbury during a visit to Mexico City during the week of April 27 by presenting a seminar on daily operational RFC procedures to CNA officials.

GASIR engineers visited RTi again from May 26-June 5 for operational training and cooperative development. Mark Woodbury of RTi followed up that session during a week-long visit to

Mexico City during the weeks of June 15 to continue forecast-team development. In anticipation of daily operation of the SPRCNA in July, the forecast team began to ingest daily data into the system during the second quarter of 1998 in order to establish basin hydrologic model states.

During the second quarter of 1998, the GSMN initiated a dialogue with the NWS and the forecast team about establishing real-time climate stations in the Río Fuerte basin in 1999. The NWS and the forecast team investigated the station locations that would strengthen precipitation estimation in the basin and improve the performance of the Río Fuerte SPRCNA, and recommended location to GSMN. When the stations are established in 1999, their real-time data should add significantly to Río Fuerte SPRCNA performance.

At a meeting on July 1, 1998, Curtis B. Barrett of the NWS formally turned over the Río Fuerte SPRCNA to Dr. Alberto Jaime Paredes, Subdirector of Technical General Subdirector, and Dr. Antonio Acosta Godínez, GASIR Director. Dr. Venancio Trueba López, PROMMA Coordinator, Ing. Carlos Espinosa González, GSMN Director, other CNA, IMTA, and NWS representatives, and other U.S. agency staff also participated in the meeting. Río Fuerte forecast team engineers from GASIR and IMTA received training and cooperative development certificates and Ing. Adriel González Hernández demonstrated the Río Fuerte SPRCNA to meeting participants. Ings. González and César Guerrero Ortega then began daily system operation.

The Río Fuerte SPRCNA has been operational since July 1, and operated daily by the GASIR forecast team. Technical aspects of SPRCNA implementation were documented and provided to CNA subsequent to system delivery (Riverside Technology, 1998a).

Task 98.2 Río Yaqui Calibration and Initialization

During the second quarter of 1998, GASIR nominated Ings. Rodrigo Piña Serrano and Juan García Soto to undertake training and cooperative development for implementation of the Río Yaqui SPRCNA. During July, they began intensive development of the Río Yaqui SPRCNA and spent three weeks in training and cooperative development on data analysis with engineers at RTi in Fort Collins, Colorado. They were joined by IMTA engineers Roberto Mejía Zermeno for one week and Benjamin Lara Ledesma for two and a half weeks. During the week of August 17, Mark Woodbury and Stan Woodcock of RTi, and Reggina Garza of the NWS SRFC spent a week in Mexico City to continue Río Yaqui SPRCNA cooperative development.

In early and mid-September, the engineers returned to RTi for three additional weeks of cooperative development and at the end of the month Mark Woodbury and other RTi representatives continued Río Yaqui cooperative development in Mexico City. In mid-October, the GASIR engineers returned to RTi to continue cooperative development and training on the Río Yaqui SPRCNA and finished during November, 1998. During the weeks of November 2 and 9, respectively, Ing. Vicente Castañeda Peña, Subgerente de Hidrología Operativa and Dr. Antonio Acosta Godínez, Gerente de Aguas Superficiales e Ingeniería de Ríos, visited RTi for week-long briefings on NWSRFS implementation in Mexico.

On December 16, the NWS formally turned over the Río Yaqui SPRCNA to Dr. Jaime and Dr. Acosta. Ings. Rodrigo Piña Serrano and Juan Garcia Soto of GASIR received certificates for SPRCNA training and cooperative development sessions and began operating the Río Yaqui SPRCNA on day-to-day basis. On December 16, the NWS and GASIR engineers demonstrated the Ríos Fuerte and Yaqui SPRCNA's and associated data base software for Ings. Martín Rodríguez Lara and Rafael Sanz Ramos, Subgerentes Técnicos of Regions II and III. Technical aspects of SPRCNA implementation were documented and provided to CNA subsequent to system delivery (Riverside Technology, 1998b).

Task 98.3 Implement Radar Plan, Phase 1

In March, 1998, Dr. Konstantine Georgakakos of the Hydrologic Research Center (HRC) and Dick Paulson of NWS met with Ing. Carlos Espinosa of SMN, Ing. Vincente Castañeda of GASIR, and Dr. Javier Aparicio Mijares and other IMTA engineers. The meeting was focused on coordination of SMN, IMTA, and HRC development of radar estimation of rainfall in the Río Fuerte basin. Following that meeting, the NWS and HRC began discussions on preparing estimates of mean areal precipitation using SMN's Guasave radar. Dr. Georgakakos and the NWS also have conducted technical discussions with Enterprise Electronic Inc. about upgrades to the Guasave radar to make volume scans and adding a workstation with adequate software to process and record volume-scan data.

Due to insufficient time in 1998 to procure an upgrade to the Guasave radar in order to make mean-areal-precipitation estimates in the Río Fuerte basin, the NWS has recommended that radar precipitation estimation be done in the Río Yaqui basin using an analysis of the SMN radar at Ciudad Obregon. In August, the NWS awarded a contract to the HRC for the implementation of precipitation estimation using radar reflectivity data in the Río Yaqui basin. HRC started to work on radar precipitation estimation in the Río Yaqui basin using an analysis of the GSMN radar at Ciudad Obregon and reported initial results in a report (HRC, 1998). Calibration of the Ciudad Obregon radar will be completed in 1999.

Task 98.4 Implement Geographic Information System (GIS) Plan, Phase 1

During January, 1998, the NWS released the report of the Geographic Information System (GIS) workshop that was held in Mexico City in November, 1997. The National Operational Hydrologic Remote Sensing Center (NOHRSC) has procured certain hardware, software, and Instituto Nacional de Estadística, Geografía e Informática (INEGI) Digital Elevation Model (DEM) data to initiate this task.

To evaluate the opportunity to undertake flood-inundation graphics in the Río Fuerte basin, Dick Paulson of NWS, Jay Day of RTi, Dr. Tom Carroll of NOHRSC, and GASIR Ings. Vicente Castañeda Peña and Carlos Marsch Moreno visited the basin in April. Ing. Rafael Sanz Ramos, Ing. Juancelmo Arrendondo Cárdenas, and other CNA staff from Region II accompanied the NWS team to a visit to the major reservoirs and selected hydrometeorological stations in the basin and San Blas.

Based on the field trip, the NWS recommended that San Blas and its vicinity are not suitable for the GIS flood inundation mapping because the town is located on a ridge well above the flood plain. Only agricultural areas located between San Blas and the Río Fuerte flood from time to time. At a subsequent meeting with Dr. Acosta, Curt Barrett and other NWS staff discussed alternative basins for implementing the GIS flood inundation mapping and concluded that the Río Panuco will be a more appropriate site for this task in 1999.

During 1998, Dr. Tom Carroll and the scientists in the NOHRSC developed the Integrated Hydrologic Automatic Basin Boundary System (IHABBS) in the Río Fuerte, Yaqui, and Mayo basins by extracting the stream and other related data from the INEGI DEM and creating flow direction grids.

On October, 1998, Dr. T. Carroll and Andy Rost of NOHRSC provided training and a demonstration on IHABBS and the Basin Unit Hydrograph Tool (BUHGTool) to Ings. Rodrigo Piña Serrano and Juan Garcia Soto of GASIR, A. Sezin Tokar of NWS, and RTi staff in Fort Collins, CO. As a follow up to the presentations, Virginia Galvin of the NWS installed and tested IHABBS and BUHGT on workstations in NWS and GASIR.

As part of the NWS investigation of the availability of DEM data in Mexico, Dr. Tom Carroll of the NOHRSC and Sezin Tokar of NWS met with David E. Greenwood and other staff of Baker Civil, a consulting engineering firm that provides a wide variety of GIS services to emergency management agencies in the United States. Baker Civil also is undertaking GIS work in Mexico. In December, Jeffery Booth of TerraPoint gave a presentation to the NWS representatives in Silver Spring on collecting Light Detection And Ranging (LIDAR) data, a new potentially cost-effective technique to collecting DEM data.

Finally, during 1998 and early 1999, NWS representatives conducted a dialogue with US Department of the Interior staff who are working with Mexican counterparts on mapping-related and water-related projects along the US-Mexican border.

Task 98.5 River Basin Data Inventories

In February, Sezin Tokar of NWS and Jay Day of RTi met with Dr. A. Acosta and GASIR staff to discuss GASIR's data holdings in the Río Yaqui basin. In April, 1998 the NWS submitted copies of the Río Yaqui river basin inventory report to GASIR (NWS, 1998c). The report verified that there are sufficient historical streamflow, precipitation, and other data to undertake implementing the Río Yaqui SPRCNA under Task 98.2.

In July 1998 the NWS completed a data inventory of the Río Mayo basin and submitted an inventory report to GASIR (NWS, 1998d). The NWS recommended to CNA that the Río Mayo SPRCNA not be implemented due to the lack of adequate historical data. The NWS suggested that the Río Mayo SPRCNA be postponed until additional streamflow and precipitation stations in the central and upstream part of the watershed are established, and additional data are collected, to which Dr. Acosta agreed.

Task 98.6 Consultants to Operational River Forecast System

In anticipation of start-up problems during the first months of operation of the Río Fuerte SPRCNA, the NWS—through RTi—provided assistance on daily system operation. This assistance included explanations of procedures for correcting data entry errors, use of run-time modifications to adjust rainfall inputs and base flow conditions, interpretation of the outputs of the system, and updates to the daily operational procedures. In the beginning, support was primarily by telephone. During the latter part of the year, RTi assisted GASIR engineers connect their workstations to the Internet and communications among RTi, NWS, and GASIR improved greatly. As a result, support now is provided through e-mail and by direct access to the system from Fort Collins and Silver Spring. Remote assistance is greatly facilitated by being able to download files, analyze problems, and help implement solutions through the Internet. Contact was generally maintained on at least a weekly basis.

At the end of August RTi staff installed an Internet Protocol (IP) network among three personal computers (PC) and the workstation running the Río Fuerte SPRCNA. Software also was installed on the PC's to allow simultaneous access to the forecast system by several GASIR engineers. RTi also coordinated with GSMN to provide remote on-line access between project workstations in Colorado and Mexico City. These steps significantly enhanced the ability of the GASIR and RTi teams to coordinate support activities.

RTi also worked with GSMN and GASIR engineers to obtain access to radar data from the Guasave radar to enhance forecaster information on areal distribution and timing of rainfall in the Río Fuerte basin. RTi also implemented a combination of manual and automatic procedures for evaluating the radar information for use in the forecast system. This included the definition of virtual stations at the centroid of each basin through which the forecaster might pass information. This information could be used by GASIR forecasters to time-distribute precipitation and estimate missing data.

During the year, RTi made several revisions to the Río Fuerte forecast system to maintain consistency between the Yaqui and Fuerte forecast systems. RTi also investigated and developed solutions to problems as they arose in a reservoir operation in the SPRCNA and a series of warning messages displayed in the RRS preprocessor output that resulted from using metric units in station definitions.

Task 98.7 Project Management

During 1998, project staff prepared the 1998 Project Implementation Plan (PIP) and discussed it with CNA officials in Mexico City in February (NWS, 1998b). Project staff prepared the 1997 Annual Report (NWS, 1998a), monthly and quarterly reports and invoices, and contracts and statements of work for contractor support. Project staff maintained a project financial and property accounting system, and a dialogue with GASIR, GSMN, IMTA, and PROMMA staff to

coordinate activities with NWS and support contractors. Project staff also organized and participated in numerous technical activities, such as the Decision Support Workshop (Task 98.8), Data Base Management and Regional Study (Task 98.9), and River Basin Inventories (Task 98.5).

During the third and fourth quarters of 1998, project staff prepared a draft 1999 CNA-NWS agreement, which Dick Paulson and Curt Barrett discussed with Dr. Acosta and Dr. Trueba during numerous visits to Mexico during this period. In December, the NWS also prepared a draft 1999 Project Implementation Plan (PIP), which provided more detail to the activities, schedules, and costs of each prospective 1999 Task. Eventually, the PIP was merged into the 1999 CNA-NWS Agreement

An additional Hewlett-Packard (HP) workstation was purchased at end of 1997 to complement the five workstations that were purchased in 1996. The new workstation was loaded with project file systems, and data and user configurations, and shipped from Silver Spring to the United States Embassy in Mexico City during the summer of 1998. During shipment, the CD and tape readers on the workstation were damaged. The workstation was repaired in Mexico City and shipped to PROMMA office by early December. In December 1998, Virginia Galvin of NWS verified that the IMTA workstation was in proper working order. Assisted by Marco Salas of GASIR, she also installed and networked the new workstation and two existing GASIR workstation, and undertook major system administrative work on them.

On October 21, 1998, Dr. Antonio Acosta of GASIR and Dick Paulson of NWS gave a presentation on Mexico Project at the American Society of Civil Engineers National Meeting in Boston. Dr. Acosta also participated in an International Round Table Discussion on Integrated Water Management that was chaired by Curt Barrett of NWS.

Project staff also coordinated SPRCNA training for Dr. Acosta and Ing. Vicente Castañeda Peña, which took place during the weeks of November 9 and November 2, respectively, at RTi in Fort Collins. Following the training, Dick Paulson and Jay Day met with Dr. Antonio Acosta and other GASIR staff on November 20 to review Dr. Acosta's visit. They also discussed regionalization, planned work on the Río Bravo SPRCNA, and the priorities of other 1999 project activities.

In early December, NWS representatives and GASIR engineers briefed World Meteorological Organization (WMO) consultants on the Río Fuerte SPRCNA and gave them a demonstration of the system. Subsequently, Curt Barrett and Dick Paulson met with the WMO consultants to brief them on the technology transfer project and discuss recommendations to strengthen PROMMA. These recommendations were considered by WMO for inclusion in a PROMMA-evaluation report to CNA.

Task 98.8 CNA Access to Other Agencies

On June 30, 1998, CNA hosted a reservoir operation Decision Support System (DSS) workshop in Mexico City that was organized by the NWS. The USBR, the Hydrologic Engineering Center of the USACE, Georgia Institute of Technology, and RTI gave hour-long presentations on DSS in managing reservoirs in the U.S. and other countries.

As a follow up to the DSS workshop, the NWS submitted suggested DSS criteria regarding CNA reservoir management to Dr. A. Acosta on July 10, 1998. The NWS suggested that the CNA implement this technology in Mexico in several phases and concentrates initially on the Río Fuerte and/or Yaqui basin. This approach will build upon the knowledge and experience that are gained there about the hydrology, reservoir operations, and use of the SPRCNA. On August 3, 1998, the NWS submitted the report "Decision Support System Workshop Summary, Mexico City, June 1998" that summarized the presentations at the meeting (NWS, 1998e).

Task 98.9 Database Management System (DBMS) and Regional Forecast System Study

One of the principal goals of PROMMA is to decentralize the management of water in Mexico. Task 98.9 was undertaken to assist GASIR plan to decentralize parts of its activities. Task objectives were to (1) define the organization and staffing of a Regional River Forecast Center (RRFC), (2) address the use of data base management systems for processing data and information, (3) define the exchange of data and information between a regional office and CNA headquarters, and (4) gain insight into the need for hydrometeorological data and forecast products. The task was undertaken by a team of NWS representatives—Dick Paulson, Jay Day, Mark Woodbury, David Curtis, and German Martinez—under the guidance of Dr. Antonio Acosta Godínez, who discussed GASIR regionalization with the representatives when they met in July 1998. Dr. Acosta also facilitated their subsequent visit to CNA Regions II and III.

Ings. Vicente Castañeda Peña and Carlos Marsch Moreno accompanied the NWS representatives on a week-long visit to CNA Regions II and III in August 1998. Their visit was hosted by Ings. Martín Rodríguez Lara and Rafael Sanz Ramos, Subgerentes Técnicos of Regions II and III, respectively. During the visit, the CNA-NWS team also met with representatives from other CNA offices, irrigation districts, water users, universities, and other organizations. During these meetings, the CNA-NWS team made presentations about implementing the SPRCNA in Mexico, solicited comments from meeting participants about their need for hydrologic data and forecast products, and discussed use of SPRCNA forecast products. To learn about existing GASIR data collection and processing practices during their visit, the CNA-NWS team visited several dams, streamgages, and climate stations, and were briefed on daily data reporting to regional offices. With the generous assistance of the State of Sonora that provided an airplane and pilot, Ing. Rodríguez hosted an aerial tour of the lower part of the Río Yaqui basin for four NWS and GASIR representatives. At the regional offices, the NWS representative also observed how hydrometeorological and reservoir data are formatted and faxed daily to Mexico City.

In order to assure that NWS had accurate information about CNA and GASIR organization and practices, German Martinez prepared two reports. One documented CNA policy and schedule for decentralizing authority from headquarters to the regions, and the second documented current GASIR's practices, and modernization and decentralization plans (Martinez, 1998a and 1998b). On October 15, the NWS representatives met in Fort Collins Colorado to review these reports, critique their visits to Mexico, and come to agreement on the technologies and human resources that CNA will need to operate river forecasting technology in the Regions.

David Curtis summarized the technologies and human resources that the team agreed were required at the regions. He prepared summary reports that documented the proposed RRFC technology and a human-resource model (Curtis, 1998a and 1998b). The human resource model documents the education, experience, and responsibilities that CNA staff must begin to acquire in 1999. The technology resources model envisioned establishment of approximately six RRFC's to support river forecasting operations in 13 regions. With this configuration, a regional office that does not include an RRFC will rely on a neighboring regional office for forecasting and other hydrologic data analysis services. Each office would require different sets of staff skills, and computer resources.

On December 14, Dick Paulson, Jay Day, and Mark Woodbury delivered the task report to Dr. Acosta and briefed him on recommendations to establish a RRFC in northwestern Mexico (NWS, 1998f). The recommendations concerned RRFC responsibilities and 1999 activities. The recommendations addressed the location of the RRFC, staffing, computer and communications infrastructure, hydrometeorological data base applications, user liaison, the establishment of a group in Mexico City to provide long-term assistance to the RRFC's, training, and schedule of RRFC implementation. As reference documents, the NWS also provided Dr. Acosta with copies of the CNA and GASIR reports prepared by German Martinez and the human and technology resource reports prepared by David Curtis.

On December 15, as part of the delivery of the Río Yaqui SPRCNA, Ings. Martín Rodríguez Lara and Rafael Sanz Ramos, Subgerentes Técnicos of Regions II and III, respectively, attended a demonstration of the Río Fuerte and Río Yaqui SPRCNA's. They also observed preliminary data base applications that the NWS recommended for further development in 1999 to modernize the exchange of data between GASIR headquarters and CNA regional offices. After the demonstrations, Dr. Acosta, Dick Paulson, Jay Day, Mark Woodbury, and other GASIR staff met with Ings. Rodríguez and Sanz to discuss regionalization-study recommendations, which Dr. Acosta agreed to discuss with senior CNA management.

Task 98.10 Satellite Precipitation Estimation

On December 24, 1998, the NWS submitted a draft report that summarized the first NWS evaluation of satellite-based precipitation estimates in Mexico to the CNA (NWS, 1998g). This report was prepared by Dr. Michael Fortune who joined the project in August 1998. After joining the project he prepared a 1998-2000 plan to evaluate two US and one Mexican satellite precipitation estimation techniques for northwestern Mexico. The techniques are the Auto-

Estimator developed by Dr. Gilberto Vicente, the Multi Spectral Technique developed by Dr. Mamadou Ba, and the EPPrePMex developed by Ing. Jorge Sanchez-Sesma of IMTA.

In September, 1998, Michael Fortune and Dick Paulson visited Dr. Acosta, Dr. Trueba, and Ing. Espinosa in Mexico City, and Ings Aparicio, Sanchez-Sesma, and other IMTA staff in Cuernavaca to discuss the plan and technical cooperation. During the meeting with Dr. Acosta, the NWS requested that the daily hydroclimate reports prepared for GASIR headquarters by Region II and III be forwarded by e-mail to Silver Spring so that daily precipitation data can be used to evaluate satellite-based estimates.

During October, NWS received precipitation observations for an entire rainy season (June through September, 1998) from CNA Regional staff in Culiacan and Hermosillo. The two regional centers continue to send daily meteorological observations for the area under their responsibilities to NWS via e-mail. Michael Fortune used these data to compare precipitation estimates from the National Environmental Satellite, Data, and Information Service (NESDIS) Auto-Estimator to GASIR precipitation data for six rain events in these regions. In early December, Michael Fortune met with Ings. Jorge Sanchez-Sesma and M. Sosa at IMTA to initiate comparisons of the IMTA satellite precipitation estimation technique with the NOAA-NESDIS Auto-Estimator technique. They compared results of using the Auto-Estimator, GASIR precipitation data, and EPPrePMex.

Later in the year in—response to CNA interest in calibrating the NWSRFS for the Río Bravo in 1999—Michael Fortune revised the plan to include evaluation of the three satellite-based techniques of precipitation estimation over border areas along the Mexico-United States border (NWS, 1998h).

98.11 GASIR/NWSRFS Model Comparison

GASIR uses an event-based model (MODCA) and its experience with evaluating daily data from historical events to forecast runoff from current significant rainfall events. The NWSRFS has been calibrated using historical hydrologic data and a continuous rainfall-runoff model in two river basins in Mexico, and also is used to forecast runoff from rainfall events. The intent of this Task was to help NWS gain further understanding of the MODCA model and to help GASIR understand strength and weakness of each model. Strict comparison of both model is inappropriate due to difference in applications and the assumptions made in their development.

Event-driven models are usually applied to evaluate direct runoff and emphasize infiltration and surface runoff. These models do not have provisions of moisture recovery between storm events and can not be used for simulation of dry weather low flows. They simulate a single event, such as a hydrograph of a single storm, and do not account for soil moisture and other residual effects from recent rainfall or drought. Many event-based models are developed for design of urban drainage systems, where they are used to estimate peak flows for areas where direct runoff is the major contributor to total runoff. GASIR developed a forecasting procedure for significant historical rainfall events using MODCA, and their experience and knowledge of the events. They

use this knowledge and experience to set MODCA model parameters based on the initial rise in an observed hydrograph. Then, they compare the initial characteristics of the current event to the historical events with similar characteristics to forecast the hydrograph and volume of the remainder of the event.

Continuous models emphasize the overall daily moisture balance of a basin. These models include algorithms that maintain a continuous water balance for a basin in order to estimate antecedent conditions for each storm event. Continuous models are developed for designing and evaluating input changes in a basin, and forecasting streamflow for the purpose of managing the watershed in the long-term, and for flood forecasting in the short-term. In the application of the NWSRFS in the Río Fuerte and Río Yaqui basins, continuous models maintain state variables and forecast short-term streamflow. The state variables also are used as initial conditions for operating the Extended Streamflow Prediction (ESP) component of the NWSRFS to make mid-term probabilistic streamflow forecasts, which are considered for reservoir operation and other water-management uses.

Throughout the last quarter of 1998, Ings. Rodrigo Piña Serrano, César Guerrero Ortega, and Adriel González Hernández of GASIR, Dick Paulson and Sezin Tokar of NWS, and Jay Day, Mark Woodbury, and Claudia Leon of RTi met on several occasions to determine the objectives, procedures, and criteria for operating the MODCA and the NWSRFS models on selected rainfall-runoff events that are documented by historical data for the Río Fuerte basin. Inflow to the Huites reservoir is important in managing water in the Río Fuerte basin and this forecast point was selected as a test site.

GASIR engineers used MODCA to simulate three historical events in January 1960, February 1973, and December 1990. They used observed precipitation and streamflow data to adjust the states of the model for the entire event, and estimated the peak discharge and volume for each event.

RTi engineers used SAC-SMA model in the NWSRFS to simulate inflows to Huites reservoirs for the entire period of 1971-1985. The state variables between various storm events were not adjusted during the simulation due to the length of data used in simulation. Under normal operating conditions, NWS forecasters often adjust state variables as observed data become available in the basin. Because the RTi engineers let the models run unadjusted for the entire 14-year period, the accuracy of the simulations was not as good as might be expected if the models were operated and used daily by NWS or GASIR forecasters. Only the February 1973 event, modeled by MODCA, was included in the 1971-1985 period. No suitable data for SAC-SMA simulation were available for the other two events modeled by MODCA. The RTi engineers and GASIR engineers each documented their findings in informal reports.

98.12 NWSRFS Documentation Translation

In order to make NWSRFS documentation more accessible to CNA staff, the NWS began to translate NWSRFS documentation from English to Spanish in 1998. Towards that goal, in early

1998, the NWS prepared a statement of work for a contractor to translate the documentation. The statement of work was advertised in the Commerce Business Daily², nearly 50 companies requested the Request for Proposal (RFP), and eight qualified proposals were received on June 18. The statement of work required each proposer to translate several pages of NWSRFS documentation, which were reviewed by the NWS and a GASIR translation team that was appointed by Dr. Acosta at the request of the NWS. The translation team consists of Ings. César Guerrero Ortega, Adriel González Hernández, José Y. Domínguez Esquivel, and Jesús C. Gutiérrez Moreno. After the proposal were reviewed, NWS procurement staff selected Pro International, Inc. (PII) of Minneapolis, Minnesota and a contract was awarded in July.

From August through November, the NWS issued four task orders to Pro International, Inc. that included approximately 1,100 pages of NWSRFS and IHABBS documentation. Throughout this period, the GASIR translation team assisted Sezin Tokar review contractor-translated documents.

In December, Edith Velosa and PII reviewers met with Sezin Tokar and the GASIR translation team in Mexico City to review GASIR's comments on the translated documents and discuss technical terms used by GASIR. PII subsequently prepared English-Spanish glossaries to assure that the technical terms used in translation are appropriate for GASIR. The NWS delivered the glossary on December 14, 1998 to GASIR for final review. PII will prepare the second draft of the translated documents for Task Orders 1 to 3 and first draft of Task Order 4 after the glossaries are accepted by GASIR. Once the documents are completed, they are being posted on NWS Internet site.

1998 Project Budget

PROMMA reimburses the NWS for its participation in this technology transfer project, but because the NWS operates under restricted personnel ceilings, most of the activities in support of this project were undertaken by qualified consultants and consulting firms. Although these consultants acted for the NWS in meetings with CNA counterparts throughout 1998, the NWS project manager maintained responsibility for managing the project, assuring that project goals are met, and documenting the project.

In 1998, the NOAA billed CNA for \$1,455,000 in U.S. dollars, for work on this project. Project costs in 1996 and 1997 totaled \$985,270.75 for a total 1996-1998 project cost of \$2,440,270.75. Approximate project expenses in 1996 through 1998 are found in Table 1. These numbers are estimated from the National Oceanic and Atmospheric Administration (NOAA) financial management system, which tracks cost by US Government fiscal year October through (September), which begins and ends three months earlier than Mexican Government's fiscal year (January through December). Project expenses largely were dedicated to NWS salary and

²The Commerce Business Daily is a daily publication in which the public is notified of contracts being prepared by the U.S. Government.

overhead costs, travel, procurement of managerial and technical consultant services, and computer hardware and software.

Appendix 1 lists the hardware and software systems that have been procured by the project, serial numbers of major hardware components, their locations, and costs. The NWS maintains responsibility for all systems that reside at NWS and contractor facilities, and will assure that all of these items are provided to the CNA prior to the conclusion of the project. The cost of maintenance contracts on the workstations under its control are included by the NWS in the hardware and software costs of Table 1.

Table 1. NWS project costs, 1996-1998 (approximate)			
	1996	1997	1998
NWS Employee Costs		\$144,000	\$144,000
Travel		\$66,000	\$50,000
Consulting services			
Management and Administrative	\$61,500	\$101,000	\$278,000
Technical		\$348,000	\$961,000
Computer Hardware and Software	\$138,500	\$126,000	\$22,000
Total	\$200,000	\$785,000	\$1,455,000

Recomendaciones del Proyecto

Las siguientes recomendaciones se pretenden reforzar los avances que se ha realizado en este proyecto. Estas recomendaciones se refieren a la coordinación del programa, el desarrollo técnico, el entrenamiento y otras relacionadas con el establecimiento del Centro Regional de Pronóstico de Ríos (CRPR).

Coordinación del Programa—La CNA y el NWS necesitan realizar una revisión formal del proyecto cada tres meses y documentar el avance que se tiene de cada actividad, también es necesario acordar las modificaciones del proyecto para las actividades en proceso e identificar las acciones que cada organización necesita realizar para completar las actividades programadas. Aunque los representantes de las dos organizaciones se reúnan frecuentemente, será necesario realizar la reunión formal trimestral para mejorar la coordinación del proyecto. Como se especifica en el acuerdo de 1999, las dos organizaciones necesitan revisar la lista de actividades que se pretenden realizar después de 1999. Finalmente, debido a que la OMM esta apoyando a la GASIR en la modernización de su red de adquisición de datos a tiempo real y a que la GSMN está modernizando su red climatológica a tiempo real, será necesario reforzar la coordinación entre la GASIR, la GSMN, el NWS y la OMM para que una cantidad suficiente de datos a tiempo real estén disponibles para apoyar el sistema de pronósticos.

Desarrollo Técnico—El NWS considera que la operación del SPRCNA a largo plazo puede ser fortalecido por numerosos desarrollos, los cuales incluyen:

- Emitir diariamente productos de pronóstico del Río Fuerte y el Río Yaqui y disseminarlos en las Regiones Norte y Noroeste respectivamente,
- Automatizar la entrada de datos hidrometeorológicos al sistema de pronóstico,
- Mejorar la calidad de los datos hidrometeorológicos,
- Reforzar la adquisición de datos hidrometeorológicos,
- Adoptar la malla del Proyecto Hidrológico de Análisis de Precipitación (HRAP) para la estimación de lluvia por malla,
- Poner a disposición de los pronosticadores del SPRCNA los datos crudos de radar,
- Evaluar los efectos del deshielo de la nieve en las avenidas que se han presentado en el noroeste de México, para determinar si se requieren datos de precipitación de nieve a tiempo real e
- Instalar “en línea”, las tablas de elevación-escurrimiento, así como algunas otras aplicaciones, para que el SPRCNA pueda tener acceso.

Entrenamiento—El entrenamiento y el desarrollo de la cooperación han sido componentes clave del proyecto y son parte de las muchas actividades que el NWS ha realizado y que se incluyen en las recomendaciones que se listan abajo para los CRPR. En particular, el NWS recomienda que:

- Al menos un ingeniero de la GASIR que haya tenido entrenamiento en el SPRCNA sea asignado al CRPR del noroeste. El ingeniero podría estar entrenado en los sistemas de pronóstico del Río Fuerte o del Río Yaqui de 1998 o en el del Río Bravo que se instalará en 1999. La GASIR deberá planificar el entrenamiento y desarrollo de la cooperación entre todos los ingenieros que serán parte del grupo de apoyo central en la Ciudad de México. También, se recomienda asignar al menos un ingeniero para cada una de las regiones donde se establecerá un CRPR,
- Los ingenieros de la GASIR o sus consultores obtengan entrenamiento de alto nivel en Sistemas Operativos UNIX y en administración de sistemas, lo cual es crítico si la GASIR adopta las aplicaciones de base de datos regional que se tratarán más adelante y
- El personal de la GASIR en la Ciudad de México apoye al NWS en el entrenamiento del personal regional del CRPR.

CRPR—En el reporte de la actividad 98.9 denominada “Sistema de Manejo de Base de Datos y Estudio de Regionalización: Establecimiento de un Centro de Pronóstico de Ríos en México”, el NWS presentó algunas recomendaciones al Dr. Acosta (NWS 1998f). Estas recomendaciones se refieren tanto a asuntos de programación como técnicos y se resumen brevemente a continuación. El NWS recomendó que:

- La CNA apruebe el establecimiento del primer CRPR en alguna de las regiones del noroeste de México,

- La CNA establezca un plan de contratación de personal para el primer año, el cual el NWS especificó en este reporte,
- La CNA adquiera una estación de trabajo, software y equipo complementario para el establecimiento del Centro. El NWS ha solicitado fondos en el acuerdo de cooperación CNA-NWS del año 1999 para iniciar la adquisición de estos equipos.
- El NWS y la GASIR desarrollen la fase 1 de las aplicaciones de la Base de Datos Integrada del Sistema Hidrológico de Pronóstico (IHFS-DB). Las aplicaciones del IHFS-DB, que es una base de datos operativa del NWS, facilitarán el intercambio de datos entre las oficinas centrales y las oficinas regionales, así como la preparación de numerosos reportes de la GASIR.
- El NWS y la GASIR realicen talleres en las oficinas regionales y centrales para la definición de los productos de pronóstico que se generarán en el CRPR y los que se utilizarán en ambas oficinas.
- La GASIR establezca un grupo nacional en la Ciudad de México que proporcione apoyo técnico a los CRPR en la medida que se establezcan en el futuro. Las recomendaciones también están dirigidas al entrenamiento del personal operativo en la preparación de nuevos productos de pronóstico así como otras actividades de apoyo.

Project Recommendations

The following recommendations are intended to strengthen the progress that has been made on this project. The recommendations concern program coordination, technical development, training, and many issues related to establishing an RRFC.

Program Coordination—The CNA and NWS need to conduct a formal project review quarterly, document the status of each task, agree on any modifications to current activities, and identify actions that each organization need to undertake to complete the tasks. Although representatives of both organizations meet frequently, a formal quarterly review will strengthen project coordination. As specified in the 1999 Agreement, the two organizations need also to revise list of activities that they intend to undertake cooperatively for the years beyond 1999. Finally, because the WMO is assisting GASIR modernize its real-time data collection networks and GSMN is modernizing its real-time climate network, it is necessary to strengthen coordination between GASIR, GSMN, NWS, and WMO so that sufficient real-time data become available to support the forecast system.

Technical development—The NWS believes that the operation of the SPRCNA in the long term will be strengthened by numerous developments, which include:

- issuing daily Río Fuerte and Río Yaqui forecast products and disseminating them to the Pacifico Norte and Noroeste Regions, respectively,
- automating the entry of hydrometeorological data to the forecast system,
- improving the quality of hydrometeorological data,
- strengthening real-time data collection,

- adopting the Hydrological Rainfall Analysis Project (HRAP) grid for gridded precipitation estimates
- making raw GSMN radar data more available to SPRCNA forecasters,
- evaluating the effect of snowmelt on flood-related events in northwestern Mexico to determine if real-time snow data are required, and
- establishing water level-discharge rating tables on line for access by the SPRCNA and other applications.

Training—Training and cooperative development have been key components of the project and they are part of many of the tasks that the NWS has undertaken and are included in many of the RRFC recommendations listed below. In particular, the NWS recommends that:

- at least one of the GASIR engineers who has SPRCNA training should be assigned to the RRFC in the northwest. The engineer could have been trained on the Río Fuerte or Río Yaqui systems in 1998 or the Río Bravo in 1999. GASIR should plan to provide this type of training and cooperative development to all engineers that will be part of a central support group in Mexico City and to at least one engineer in each of the regions where RRFC's will be established,
- GASIR engineers or consultants become highly trained in UNIX operating systems and system administration, which is critical if GASIR will adopt the regional data base applications discussed below, and
- GASIR staff in Mexico City assists NWS train regional RRFC staff.

RRFC—The NWS made numerous recommendations in the Task 98.9 report, “Database Management System and Regionalization Study: Establishment of a Regional River Forecast Center in Mexico”, that was provided to Dr. Acosta (NWS 1998f). These recommendations concerned a wide range of programmatic and technical issues, which briefly are summarized below. The NWS recommended that:

- CNA approves the establishment of the first RRFC in one of the northwestern CNA regions,
- CNA establishes a first-year staffing plan, which the NWS specified in the report,
- CNA acquires a workstation and associated hardware and software to establish the center. NWS has requested funds in the 1999 CNA-NWS agreement to begin to procure these items,
- NWS and GASIR develop Phase 1 Integrated Hydrologic Forecast System Data Base (IHFD-DB) applications. An operational NWS data base, IHFS-DB applications will facilitate the exchange of data between headquarters and the regional office, and the preparation of numerous SPRCNA reports,
- NWS and GASIR conduct workshops in regional and headquarters offices to identify RRFC forecast and other data products that will be needed at both levels, and
- GASIR establishes a national group in Mexico City that will provide technical support to the RRFC's as they are established in the future. The recommendations also addressed training operation staff, preparing new forecast products, and other support activities.

Summary

The NWS and CNA initiated cooperation in transferring river forecasting technology to Mexico in late 1996 and, during 1997 and 1998, cooperated on establishing the Río Fuerte and Río Yaqui SPRCNA. Development of the Río Fuerte system began in 1997 and, along with the Río Yaqui system, was completed in 1998; both systems now are in daily operation. Six engineers—four from GASIR and two from IMTA—completed full SPRCNA training and cooperative development at RTI. During 1998 the NWS also undertook numerous tasks that provided CNA with information about reservoir operation DSS and met with numerous regional staff and potential SPRCNA users to evaluate the establishment of an RRFC in northwest Mexico. The NWS also began to evaluate the use of radar and satellite precipitation estimation to complement the current gage network, compared GASIR and NWSRFS models, translated considerable NWSRFS documentation from English to Spanish, and began to evaluate GIS technology in GASIR applications.

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Acronyms

The following acronyms appear in this report.

CNA	Comisión Nacional del Agua
DEM	Digital Elevation Model
DSS	Decision Support System
GASIR	Gerencia de Aguas Superficiales e Ingeniería de Ríos
GIS	Geographic Information System
GSMN	Gerencia de Servicio Meteorológico Nacional
HP	Hewlett Packard
HRAP	Hydrological Rainfall Analysis Project
HRC	Hydrologic Research Center
IHABBS	Integrated Hydrologic Automatic Basin Boundary System
IMTA	Instituto Mexicano de Tecnología del Agua
INEGI	Instituto Nacional Estadística Geografía e Informática
NOAA	National Oceanic and Atmospheric Administration
NOHRSC	National Operational Hydrologic Remote Sensing Center
NWS	National Weather Service
NWSRFS	National Weather Service River Forecast System
PROMMA	Programa de Modernización del Manejo del Agua
RFC	River Forecast Center
RRFC	Regional River Forecast Center
RTi	Riverside Technology inc.
SEMARNAP	Secretaría de Medio Ambiente, Recursos Naturales y Pesca
SIGA	Sistema Geográfico de Información del Agua
SPRCNA	Sistema de Pronóstico en Ríos de la CNA
SRFC	Southeast River Forecast Center
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
WGRFC	West Gulf River Forecast Center
WMO	World Meteorological Organization